
Clinical Competence in Hemodynamic Monitoring

A Statement for Physicians From the ACP/ACC/AHA Task Force on Clinical Privileges in Cardiology

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The granting of clinical staff privileges to physicians is one of the primary mechanisms used by institutions to uphold the quality of care. The Joint Commission on Accreditation of Healthcare Organizations requires that the granting of initial or continuing medical staff privileges be based on assessments of applicants against professional criteria that are specified in the medical staff bylaws. Physicians themselves are thus charged with identifying the criteria that constitute professional competence and with evaluating their peers accordingly. But the process of evaluating a physician's knowledge and competence is often constrained by the evaluator's own knowledge and ability to elicit the appropriate information, a problem that is compounded by the growing number of highly specialized procedures for which privileges are requested.

This guideline is one of a series developed by the American College of Physicians, the American College of Cardiology, and the American Heart Association to assist in the assessment of physician competence in hemodynamic monitoring. The minimum education, training experience, and cognitive and technical skills necessary for the competent performance of hemodynamic monitoring are specified;

whenever possible, these are based on published data linking these factors with competence in certain procedures or, in the absence of such data, on the consensus of expert opinion. For the procedure discussed in this paper, published data are fragmentary and consensus of experts has been used. These guidelines are applicable to the practice setting and can accommodate a number of ways physicians might substantiate competence in the performance of specific procedures.

Overview of the Procedure

Hemodynamic monitoring has become widely and frequently used by physicians from multiple medical specialties during the 20 years since pulmonary artery pressure monitoring and cardiac output measurements were first described by Swan and Ganz with the flotation catheter (1). Hemodynamic monitoring includes pressure measurement in the pulmonary artery, central venous system, and arterial system and the measurement of cardiac output. This paper is concerned with pressure measurement in the pulmonary artery and the ancillary right ventricular pressures and cardiac output measurements. The issues relating to intra-arterial and central venous monitoring are similar to those considered here, but the training and skills involved in interpretation are less demanding and Doppler techniques and automated cuff readings have reduced the need for intra-arterial monitoring.

Credentials committees should emphasize the qualifications and training of the physician who performs the proce-

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dures and not the specialty or subspecialty to which the physician belongs. Primary focus should be on the competence to perform the procedure and to interpret and apply the data.

Every physician who performs hemodynamic monitoring should understand the indications for the procedure, be technically competent with insertion techniques, be familiar with potential complications and their prevention, and have the ability to interpret the data obtained. In addition, *the physician must assume* responsibility for the integrity of the data and its use in patient management while the monitoring apparatus is in place. This facet of competence is more important and requires greater training, experience, and judgment than the technical aspects.

Critical attention should be given to the indications for hemodynamic monitoring. As outlined in Table 1, there are many conditions in which hemodynamic monitoring may be indicated, but many patients with these conditions do not require monitoring before clinical decisions can be made. Recent reviews (2,8) emphasize the need for discriminating use because of ambiguous indications, especially in acute myocardial infarction. Similar problems relating to indications exist in most of the conditions and settings where pulmonary artery catheterization is used. These concerns will continue until studies are conducted that compare outcomes in similar patients who undergo hemodynamic monitoring with outcomes in patients who do not receive monitoring. Such studies are difficult and are unlikely to be performed.

In one community, hemodynamic monitoring for acute infarction patients with hypertension, congestive heart failure, and cardiogenic shock increased from 7.2% in 1975 to 19.9% in 1984 (3), but no benefit related to improved patient outcome could be discerned. This study highlights the difficulty in assessing indications and emphasizes the need for sound clinical judgment. A similar increase in the use of hemodynamic monitoring for other clinical conditions has occurred without controlled trials, critical assessment of outcomes, or formal assessment of the risk/benefit ratio. In the current era of cost containment and because of the inconvenience and potential risks, these issues merit further study and critique.

In addition to assessing competence to perform this procedure, hospitals should assess the frequency, appropriateness, complications, and outcomes of hemodynamic monitoring.

Since instruments for hemodynamic monitoring are manufactured by many different vendors, each physician credentialed to perform hemodynamic monitoring should be familiar with the instruments used in his own hospital. Physicians trained in one institution but practicing in another may find the equipment sufficiently different to require special orientation. *Relegating the total responsibility for equipment setup, trouble-shooting, calibration, or other technical de-*

tails to nursing or technical personnel is unacceptable, because the integrity of the data is always the physician's responsibility.

Justification for Recommendations

Privileges to perform hemodynamic monitoring should be granted on an individual basis since there are several disciplines involved in training and performing the procedures and the pathways to competence are varied.

Understanding the details of data collection (including instrumentation management and timely recognition of pressure wave forms), ability to trouble-shoot technical problems and quickly recognize artifacts, and detailed knowledge of the fluid and pharmacological interventions that follow placement of the catheter are more important and more difficult than knowing how to perform the procedure technically. Careful patient follow-up to avoid complications or treat them in a timely fashion is an integral part of the responsibility of the physician who agrees to do the procedure.

Indications, Contraindications, and Complications

Table 1 lists the major indications for performing hemodynamic monitoring. This procedure provides physiological data that cannot be obtained with similar precision and accuracy by any other method. These data can be valuable in understanding clinical presentations and determining therapy. However, there are no good studies demonstrating that better definition of hemodynamics results in improved patient management and/or more favorable outcomes (3). For example, most patients with acute pulmonary edema who respond rapidly to routine therapy do not benefit from hemodynamic monitoring, because the short-term outcome in these patients is favorable and they can be followed adequately by clinical examination that includes cuff blood pressure measurements, urinary output, blood gases, etc. In this case, and in all indications outlined in Table 1, clinical judgment is the key to appropriate use of the procedure.

Hemodynamic monitoring should be used only when a specific management decision is being considered and when the physician is committed to act on the data obtained from hemodynamic monitoring. Less-specific indications, including the idea that the physician would be better informed, that it is "routine" to perform hemodynamic monitoring in certain clinical settings, or that there is little reason not to do it are not adequate justification. The hazards, inconvenience to the patient, and expense of the procedure are important considerations, and the procedures need to be specifically justified by the physician for each patient.

Table 1. Some Common Indications for Hemodynamic Monitoring

To establish or assist in establishing a "specific" diagnosis
Ventricular septal defect vs. mitral regurgitation in acute myocardial infarction
Differentiating cardiac from noncardiogenic pulmonary edema
Right ventricular myocardial infarction in selected patients with inferior myocardial infarction
Pulmonary embolism
Differentiating angina from other causes of chest pain in patients with uninterpretable electrocardiograms (e.g., left bundle-branch block)
To help direct management in medical patients in whom knowledge of intravascular pressures and flow will alter treatment when clinical estimates (e.g., by bedside examination, chest x-ray, or fluid challenge) are not reliable.
Such patients are usually in a complex and unstable condition
Complex cardiac conditions
Myocardial infarctions complicated by
Hypotension unresponsive to volume challenge
Marked hemodynamic instability requiring intravenous inotropic or vasoactive drugs or mechanical assist devices
Hypotension and/or congestive heart failure
Selected patients with complicated unstable angina requiring intravenous nitroglycerin and other vasoactive agents
Patients whose pulmonary edema may be cardiogenic or noncardiogenic
Patients whose volume or cardiovascular status is uncertain and in whom a diuretic or fluid challenge would be unsafe or would yield equivocal results
Selected patients with right ventricular infarction
Critically ill medical patients, often with associated cardiac disease
Gastrointestinal hemorrhage
Sepsis
Respiratory failure
Renal failure
Pancreatitis
Dialysis with complications
Drug overdose
Selected ventilator patients (e.g., to provide optimal positive end-expiratory pressure and volume therapy in adult respiratory distress syndrome)
To assist management of surgical patients. (Careful, systematic assessment of risk in cardiac patients with particular attention to recent or recurrent ischemia, ventricular function, and arrhythmias is important. Problems in fluid and electrolyte management are important considerations in many of these patients.)
Cardiac surgery
Valve replacement (multiple, elderly)
Severe associated pulmonary disease
Coronary artery bypass grafting
Resection of ventricular aneurysm
Vascular procedures
Dissecting aneurysm
Resection of thoracic aneurysm
Abdominal aortic aneurysm
Prostatic resection
Extensive intra-abdominal resection (tumor)
Prolonged orthopedic procedures (elderly)
Severe burns
Multiple injuries
Management of high-risk obstetrical patients
Known cardiac disease
Toxemia
Suspected abruptio placenta
Clinical investigation
Developing new concepts, assessing prognostic subsets, assessing hemodynamic responses to new therapies

The major complications related to hemodynamic monitoring are listed in Table 2. Contraindications to the procedure are relatively few. When no useful therapeutic ap-

proach exists because of the extent of the patient's associated diseases (particularly central nervous system abnormalities), performing the procedure is contraindicated.

Table 2. Complications of Hemodynamic Monitoring*

Puncture site complications
Inadvertent arterial puncture (for central venous access)
Hemorrhage
Phlebitis
Thrombosis
Air embolism
Pneumothorax
Infection
Insertion and postinsertion arrhythmias
Systemic infection
Pulmonary complications
Pulmonary artery thrombosis
Pulmonary artery rupture
Pulmonary infection
Balloon rupture
Valvular damage and thrombotic vegetation
Catheter knotting/entanglement
Obtaining inadequate or poor quality data or inappropriately interpreting data

*Complications are infrequent, usually of minor importance, and rarely life-threatening. Accurate data on the frequency of complications in clinical practice are not available. Reports of minor complications, such as nonsustained arrhythmia and local infections/inflammations, are common (15-40%). Major complications such as pneumothorax, sustained arrhythmias, septicemia, and important pulmonary complications occur in 3-4% of patients, usually those who are critically ill. The severity of illness in the patient as well as the expertise of the operator are major determinants of the rate of complications (5,7).

Minimum Training Necessary for Competence

The varied training of physicians who perform hemodynamic monitoring makes the role of the credentials commit-

tee critical. Physicians who are certified in subspecialties such as cardiology, pulmonary medicine, anesthesiology, critical care medicine, and some surgical specialties are likely to have had supervised training that exceeds the requirements. Other training settings, such as general internal medicine or family medicine, may require special arrangements between the trainee and the program director to provide the breadth of training required for competence.

The specific number of procedures needed in a training program to acquire the technical and cognitive skills in hemodynamic monitoring (see Tables 3 and 4) will vary, depending on the aptitude and dexterity of the physician, the clinical and institutional setting in which the training occurs, and the backup and collaboration available to the physician. Twenty-five is the minimum number of procedures required to acquire competence as an independent operator. This number is the consensus of many expert consultants. A small number of procedures done under "controlled" circumstances in patients with minimal or no circulatory abnormalities (e.g., as a prelude to general anesthesia in elective surgical patients) will not provide adequate training.

In light of these variations in training programs, requests for clinical privileges in hemodynamic monitoring should be evaluated on the basis of the actual skills and experience of the candidates rather than the type of training program they have completed. The cognitive and technical skills of the candidates should be confirmed by the training director in writing; in some cases, verification or clarification through follow-up correspondence with the program director or observation of the physician performing the procedure by a staff physician who is an acknowledged teacher or expert in

Table 3. Cognitive Skills Needed to Perform Hemodynamic Monitoring

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1. Knowledge of indications with emphasis on the subtleties involved. Data obtained should be needed to make management decisions and improve patient outcome. Obtaining high quality hemodynamic data, even though abnormal and sometimes contrary to clinical judgment, does not of itself constitute an adequate indication
 2. Knowledge of the anatomy of neck, central venous system, peripheral arterial tree, heart, and lungs
 3. Knowledge of and ability to recognize pulse waveforms for the wide array of hemodynamic conditions for which the procedures are indicated
 4. Knowledge of and ability to perform the hemodynamic calculations that are possible and necessary (e.g., cardiac output, peripheral and pulmonary vascular resistance, and derived measurement such as stroke volume, ventricular stroke work)
 5. Understanding the importance of and ability to recognize artifacts, clinical circumstances under which data may be misleading and/or difficult to obtain (e.g., situations when pulmonary capillary wedge pressure does not appropriately reflect left ventricular end-diastolic pressure or effect of pulmonary ventilation/ventilators on measurements)
 6. Knowledge of fluid and electrolyte balance and their roles in altered hemodynamics
 7. Knowledge of the pharmacological effects of the drugs that alter preload, afterload, and inotropic state
 8. Knowledge of the complications of hemodynamic monitoring and appreciation of the approaches and techniques necessary to minimize their occurrence, recognize their presence, and treat them promptly
 9. Knowledge of the interaction of multiple pathophysiological states and diseases that are present in many critically ill patients undergoing hemodynamic monitoring
 10. Knowledge of the importance of and approach to assessing blood gases, pulmonary ventilation, and metabolic derangements
 11. Ability to communicate and document the results of the examination to the patient, to the medical record, and to other physicians
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Table 4. Technical Skills Needed to Perform Hemodynamic Monitoring

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1. Ability to perform surgical sterile technique
 2. Ability to perform venous access from two (or multiple) sites with the percutaneous technique. Ability to do cut-downs is also desirable
 3. Ability to perform arterial access (primarily radial artery puncture) although ability to do arterial cut-down is desirable
 4. Ability to operate all instrumentation involved in hemodynamic monitoring including catheters, introducers, strain gauges and recorders and to perform calibration, balancing, and zeroing techniques
 5. Knowledge and ability to correct ("trouble shoot") common artifacts and technical problems with recording instrumentation and catheter/tubings
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hemodynamic monitoring may be required. Each physician in training should keep a log of procedures done. The log should include patient identification, date, diagnosis, indication, problems and complications, and duration of monitoring.

For physicians currently in practice, other arrangements might provide competence. These include courses in which the trainee becomes familiar with all aspects of hemodynamic monitoring and performs at least 25 procedures during the course work. The completion of a short course or workshop that offers limited exposure to cognitive background data or technical skills will not by itself result in competence.

Maintenance of Competence

Follow-up of each physician's performance and timely review of patient outcomes are responsibilities of the credentials committee. Many hospitals make these assessments by having the physician who performs the hemodynamic procedure fill out a simple form for each procedure, which is included in the patient's record. An alternative approach is to include a comprehensive procedure note in the body of the chart, which could be submitted to the credentials committee on a timely basis for review and documentation. In addition, each physician should keep a log of procedures done, including indications, complications, and duration of monitoring.

Maintaining competence in hemodynamic monitoring requires continuing experience and will depend on the total

experience of the physician and the hospital setting in which the practice occurs. Physicians with extensive experience who work in hospitals where these procedures are done infrequently may be able to maintain competence with a minimum number of continuing procedures, perhaps as few as 12 per year.

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